ANALYSIS AND DESIGN OF SYMMETRIC AND ASYMMETRIC BUILDING FRAME SUBJECTED TO GRAVITY LOAD

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ABSTRACT

In present scenario, most of the buildings are often constructed with irregularities such as soft storey, unsymmetrical layout, Torsional irregularity of in-fill walls, vertical and plan irregularity, etc. Past earthquake studies shown that the most of the RC buildings having such irregularities were severely damaged under the seismic ground motion. In this study the modeling and analysis works has been done based on software named "Staad Pro" and "SAP: 2000". The analysis was performed on symmetric and asymmetric frame to study the behaviour of bending moments, shear forces and axial forces. The Shear Force in X direction was found similar in magnitude in both types of frames. In Y-direction the Shear force was found higher in Asymmetrical frame as compare to symmetrical. The Bending moment in X and Y direction was found higher in symmetrical frame as compare to Asymmetrical frame. But it was observed that the bending moment in X-Y direction suddenly decreased after 4th storey of symmetrical building. The behaviour of axial force in column was found similar in magnitude in both Asymmetric and symmetrical frame. The Symmetric frame was found more Cost Effective with respect to Asymmetric frame as the volume of material being used was more in Asymmetric model.

Keywords: Symmetric and Asymmetric frame, Shear Force, Bending moment, axial force, Stadd Pro.

1. INTRODUCTION

In every aspect of human civilization we needed structures to live in or to get what we need. But it is not only building structures but to build efficient structures so that it can fulfill the main purpose for what it was made for. Here comes the role of civil engineering and more precisely the role of analysis of structure. The design consists of symmetric and asymmetric plan of building. The building is designed for the six storey residential flats. There are many classical methods to solve design problem, and with time new software's also coming into play. Asymmetrical buildings undergo large amount of torsion and hence extreme corners are subjected to heavy force. Avoid asymmetrical buildings like: I, L,U, and T shape buildings. As CoM & CoR coincide in plan twisting will not occur due to earthquake. Building will need to resist the horizontal inertia force only. Symmetrical plans like Rectangular, Square, Polygonal or Circular are favourable.

A lack of symmetry produces torsional effects that are sometimes difficult to assess, and can be very adverse. The preferred method of minimizing torsional effects is to select floor plans that are regular and reasonably compact. Complex plan buildings should be divided by seismic separation joints introduced between rectangular blocks. The behaviour of buildings during earthquakes will be satisfactory only if all measures are taken to provide a favorable failure mechanism. A special account must be taken so that torsional effects do not endanger or preclude the global ductile behaviour of the structure. Buildings with an asymmetric distribution of stiffness and strength in plan undergo coupled lateral and torsional motions during earthquakes. Because of torsion, the seismic demands of asymmetric buildings increase above those required by just translational deformation. It is well-known that the larger the eccentricity between the centre of stiffness and the centre of mass, the larger the torsional effects. An important aspect of the inelastic behaviour of asymmetric structures is the considerations of the degree of control over inelastic twist. One of the design aims should be to restrain the system against unrestricted inelastic twist. In the structures,

which remain elastic during an earthquake, torsional vibrations may cause significant additional displacements and forces in the lateral load resisting elements. However, the design of the majority of buildings relies on inelastic response. In that case torsional motion leads to additional displacement and ductility demands. Hence, the relevance of current code recommendations, based on elastic torsional response, is open to questions. In this study the modeling and analysis works has been done based on software named "Staad Pro" and "SAP:2000".

2. LITERATURE REVIEW

Many researchers has been worked on the behaviour of symmetry and asymmetry of buildings. Following of them are

- Dr. S.D. Bhole in *'Comparative study of Symmetrical and Asymmetrical L shaped and T shaped Multistorey Building Gravity and Seismic Loads with varying Stiffness*' discussed an overview of Performance of the Torsionally Balanced and Unbalanced Structure and so the significant changes in parameters such as Deflection, Bending Moment and Shear Force
- L.G.Kularkar in *'Analysis and Design of Multi-storey Building using Composite Structure*' discussed about design analysis of G+5 Building using Composite Structure. A three dimensional modelling and analysis of structure are carried out with the help of SAP 2000 Software
- Ravish Khan & Sangeeta Shinde in '*Analysis of Diagrids Using Symmetric and Asymmetric Plan Geometry'* observed that the top storey Displacement of Symmetrical Model is less than Asymmetrical Model by 26%.
- Mr. Gajendra studied about Analysis and Design of Multi-storey Building by using STAAD Pro study the efficiency of certain Civil Engineering Application Software.

3. METHODOLOGY

This research work includes various stages for symmetrical and asymmetrical frame.

Stage-1 Planning of symmetrical and asymmetrical building.

Stage-2 Material & Geometric Properties

Stage-3 Assign the Load & Load combinations on frame

Stage-4 Modelling of symmetrical and asymmetrical building frame

Stage-5 Analysis of symmetrical and asymmetrical building frame.

Stage-6 Design of symmetrical and asymmetrical building

Stage-7 Analysis of Datasheet

Stage -1 Planning of symmetrical and asymmetrical building

The following plans are having approximate same area with different geometrical properties.

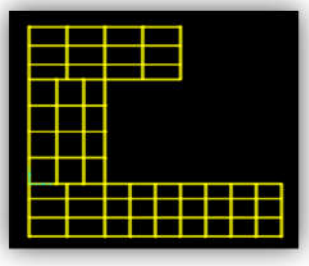


Figure 1: Asymmetrical plan

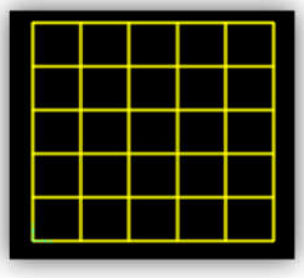


Figure 2: Symmetrical plan

Figure 1 shows the asymmetrical plan and figure 2 shows symmetrical plan building.

Stage-2 Material & Geometric Properties

The following properties of material and geometry used in analysis of symmetrical and asymmetrical building

- Grade of Concrete used: **M25**
- Grade of Steel Used: **Fe415**
- Area of plan: **625 m^2**
- No. of storey: **G+5**

A six storey frame with 150 mm thickness of slab resting on four numbers of beams 300 x 300mm cross section of span 4m and 300 x 300mm four numbers of columns is considered for the analysis. We change the sizes of two columns to 400 x 400mm to make it asymmetric in plan. The above frame has been modeled in two ways,

Table 1: Geometrical data for symmetrical and asymmetrical building

Symmetrical Frame	**Asymmetrical Frame**
Size of Beam: 400mm X 400mm 300mm X 550mm	Size of Beam: 300mm X 520mm
Size of Column: 300mm X 450mm : 900mm X 400mm : 400mm X 900mm	Size of Column: 400mm X 500mm : 450mm X 450mm : 500mm X 400mm : 450mm X 550mm

Stage-3 Assign the Load & Load combinations on frame

As per IS 875 Part I (1987), "Indian Standard Code of Practice for Design Loads (Other Than Earthquakes) For Building and Structures Part 1: Dead Loads –Unit Weights of Building materials and stored materials", Second Revision, Bureau of Indian Standards (BIS), New Delhi, 1987

Dead Load is follows:

Table 1: Dead load data for symmetrical and asymmetrical building

Symmetrical Frame	**Asymmetrical Frame**
BEAM: 54.00 X 25 = 1350 KN 198.00 X 25 = 4950 KN	***BEAM:*** 406.212 X 25 =10155.3 KN
COLUMN: 11.70 X 25 = 292.5 KN 52.66 x 25 = 1316.5 KN 158 X 25 = 3950 KN	***COLUMN:*** 157.275 X 25 = 3931.875 KN 7.40 X 25 = 185 KN 106 X25 = 2651.75 KN 9.052 X 25 = 226.3 KN
TOTAL DEAD LOAD= 11859 KN	**TOTAL DEAD LOAD= 17150.225 KN**

As per IS 875 Part II (1987), "Indian Standard Code of Practice for Design Loads (Other Than Earthquakes) For Building and Structures Part 2: Imposed Loads", Second Revision, Bureau of Indian Standards (BIS), New Delhi, 1987

Live load=2 KN/m^2 (As per NBC provision)

Stage-4 Modelling of symmetrical and asymmetrical building frame

Building frame with the following geometrical types are considered for analysis in for seismic and gravity loading in each variation in plan size.

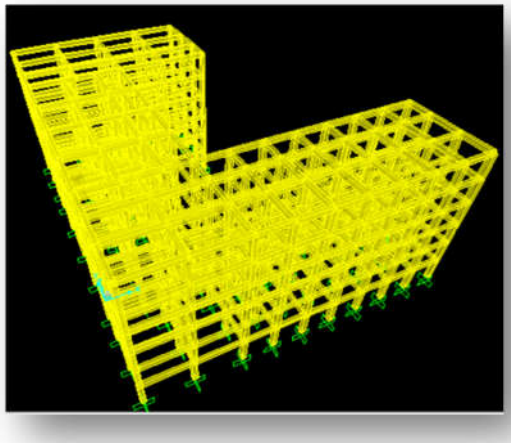


Figure 3: Isometric view of Asymmetric building

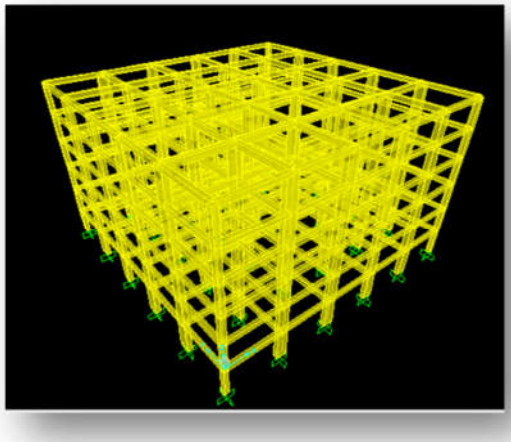
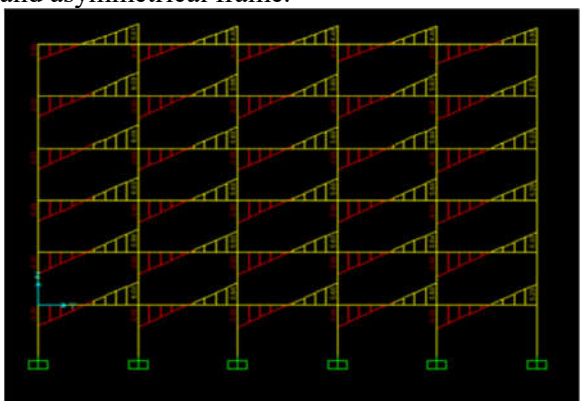


Figure 4: Isometric view of Symmetric building

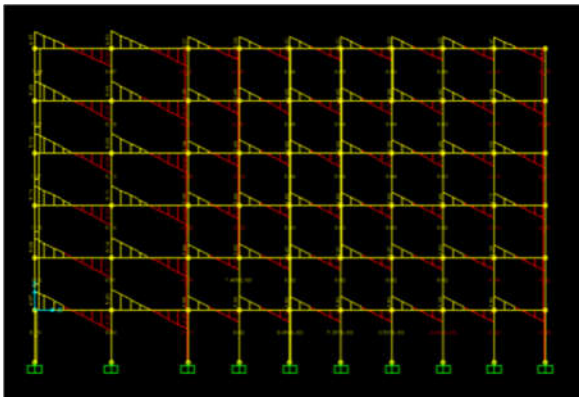
The above figure has been shows that multistory building structure frame G+5 has been modeled in SAP and analysis software with given material properties and specifications.

Stage-5 Analysis of symmetrical and asymmetrical building frame

The analysis of symmetrical and asymmetrical frame has been done with the help of Stadd Pro tool. We carried out the analysis of shear force, bending moment, axial force and deflected shape of symmetrical and asymmetrical frame.



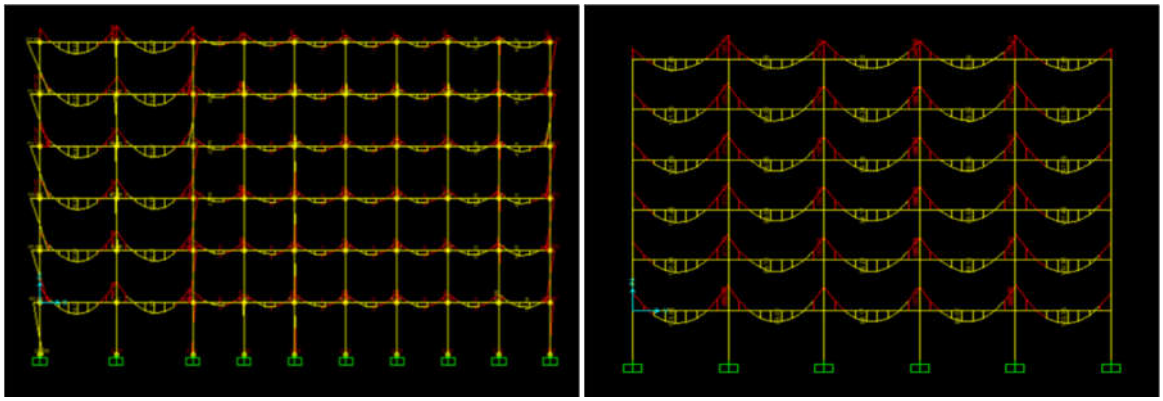
a)



b)

Figure 5: a) Shear Force Diagram of Asymmetric Structure
b) Shear Force Diagram of symmetric Structure

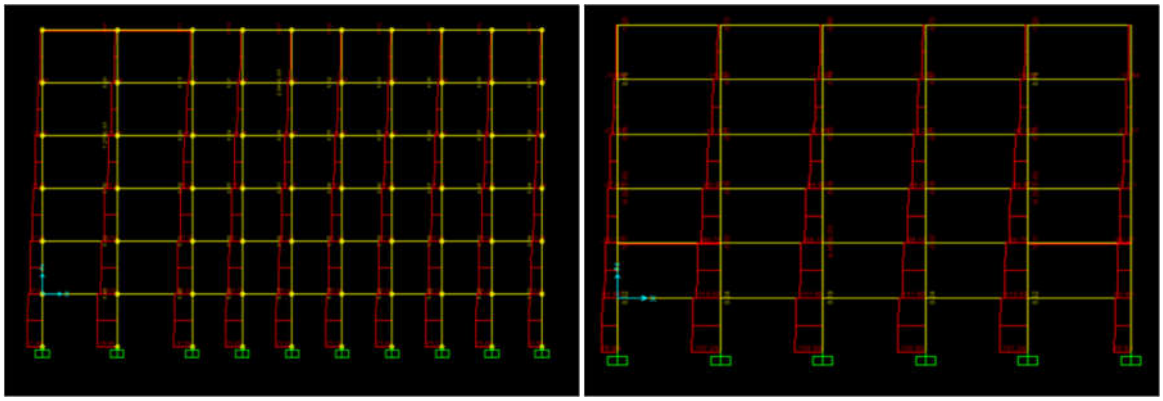
The figure 5(a) shows the Shear force analysis of Asymmetric Structure and figure 5(b) shows the Shear force analysis of symmetric Structure.



a) b)

Figure 6: a) Bending Moment Diagram of Asymmetric Structure
b) Bending Moment Diagram of symmetric Structure

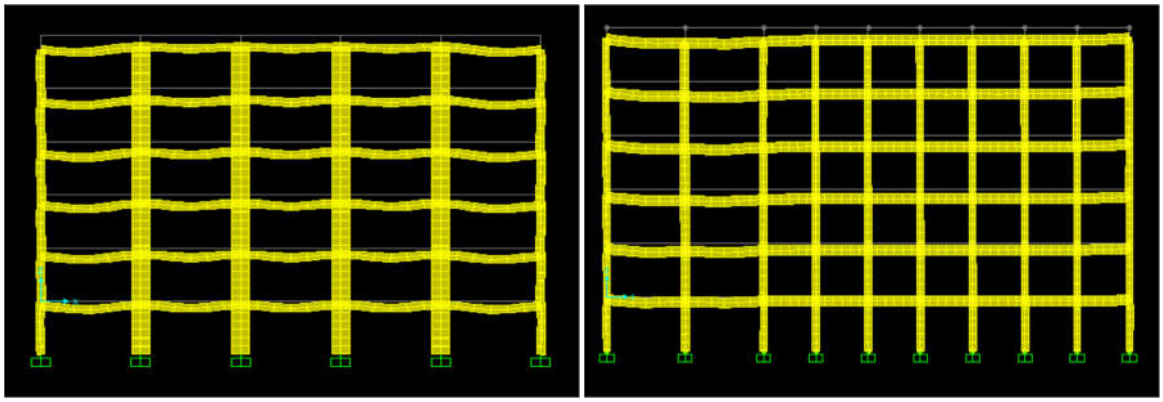
The figure 6(a) shows the Bending moment analysis of Asymmetric Structure and figure 6(b) shows the Bending moment analysis of symmetric Structure.



a) b)

Figure 7: a) Axial force Diagram of Asymmetric Structure
b) Axial force Diagram of symmetric Structure

The figure 7(a) shows the axial force analysis of Asymmetric Structure and figure 7(b) shows the axial force analysis of symmetric Structure.



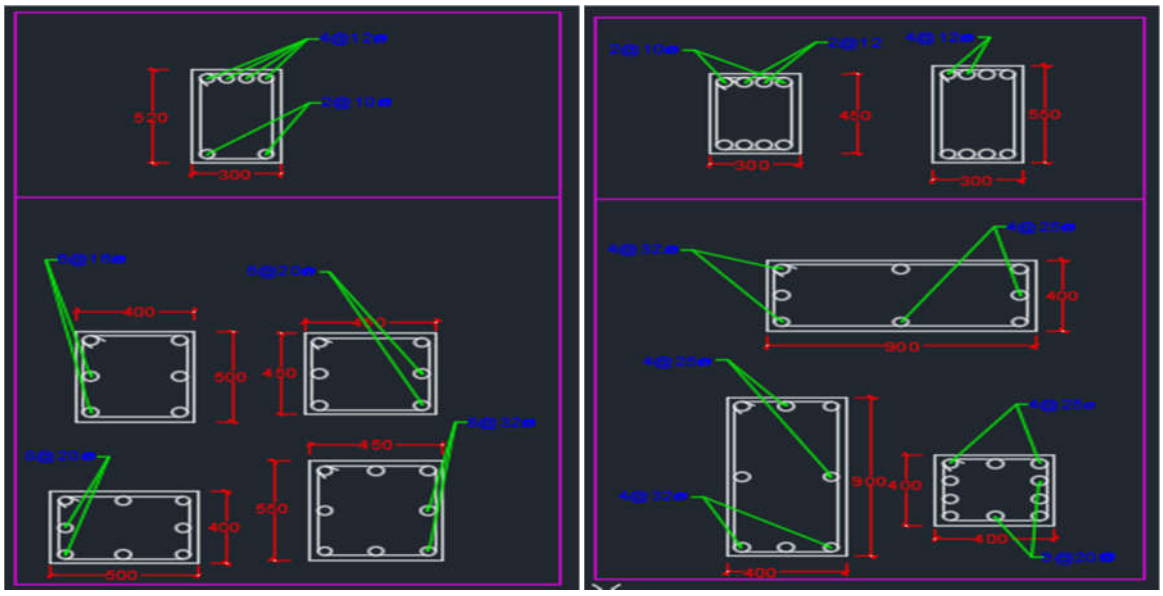
a) b)

Figure 8: a) Deflected shape of Asymmetric Structure
b) Deflected shape of symmetric Structure

The figure 8(a) shows the deflected shape of Asymmetric Structure and figure 8(b) shows the deflected shape of symmetric Structure.

Stage-6 Design of symmetrical and asymmetrical building

The designing of beams and column in Asymmetrical and symmetrical frame has been done with the help of Stadd Pro tool with following consideration of IS456:2000 and detailing of reinforcement with IS13920.



a) b)

Figure 9: a) Beam and column reinforcement detailing of Asymmetric Structure
b) Beam and column reinforcement detailing of symmetric Structure

The figure 9 (a) shows the reinforcement detailing of Asymmetric Structure and figure 9 (b) shows the reinforcement detailing of symmetric Structure.

Stage-7 Analysis of Datasheet

- Total volume of material (R.C.C.) being used in Symmetrical frame is 476.36 m^3.
- Total volume of material (R.C.C.) being used in Asymmetrical frame is 686.478 m^3.

4. RESULT AND DISCUSSION

The following results show the variation in Shear force, Bending Moment and axial force in asymmetrical and symmetrical frame.

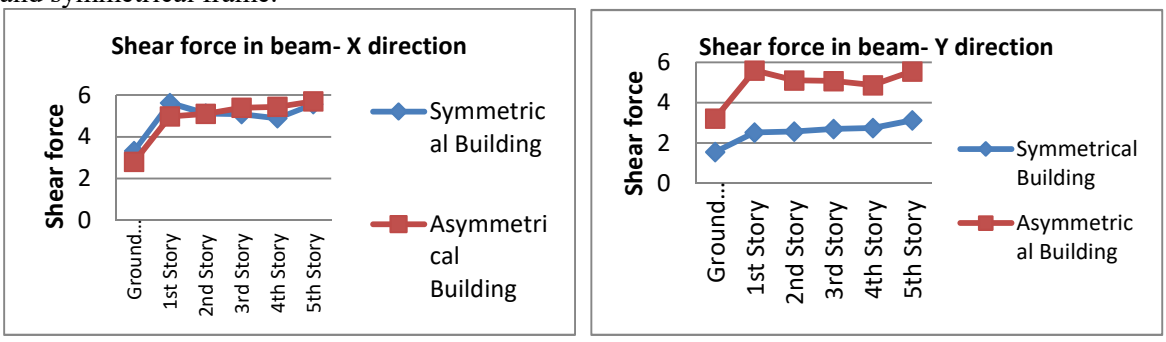


Figure 10: a) Comparison between Shear Force of Asymmetric and symmetrical Structure in X direction
b) Comparison between Shear Force of Asymmetric and symmetrical Structure in Y direction

The Shear Force in X direction was found similar in magnitude in both types of frames. In Y-direction the Shear force was found higher in Asymmetrical frame as compare to symmetrical frame (Figure 10).

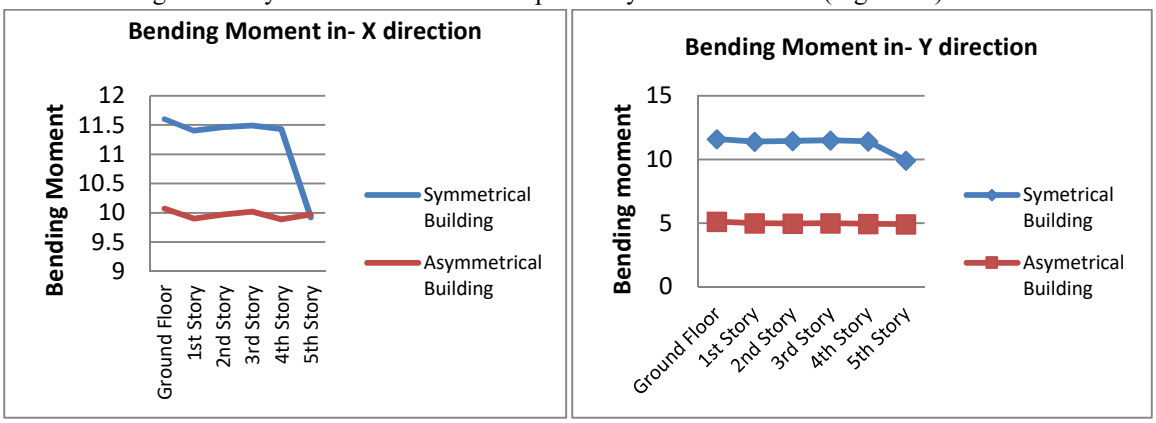


Figure 11: a) Comparison between bending moment of Asymmetric and symmetrical Structure in X direction
b) Comparison between bending moment of Asymmetric and symmetrical Structure in Y direction

The Bending moment in X and Y direction was found higher in symmetrical frame as compare to Asymmetrical frame. But it was observed that the bending moment in X-Y direction suddenly decreased after 4th storey of symmetrical building (figure -11).

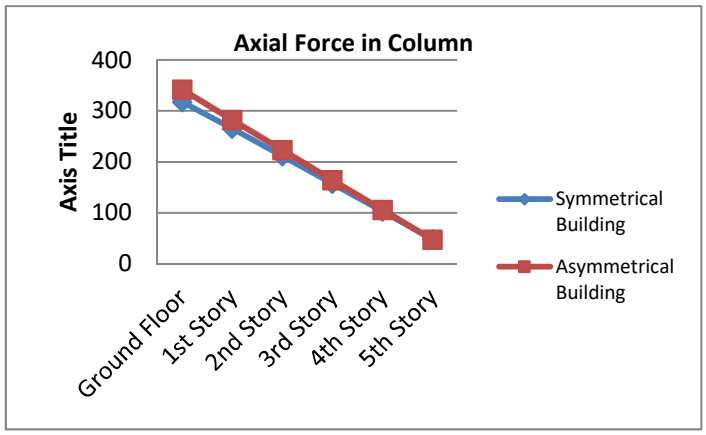


Figure 12 Comparison of axial force in column of Asymmetric and symmetrical Structure

The behaviour of axial force in column was found similar in magnitude in both Asymmetric and symmetrical frame.

5. CONCLUSIONS

The Conclusions of this research paper are:

- The Symmetric model provides more Gross Leasable Area (GLA) as compared to Asymmetric model. Hence, *Area Utilization* will be more.
- The Load Distribution in Symmetric model is more uniform as compared to asymmetric model.
- The requirement of reinforcement is more in asymmetric frame than the symmetric frame.
- The Symmetric model is more *Cost Effective* with respect to Asymmetric model as the volume of material being used is more in Asymmetric model.

6. REFERENCES

- Ravish Khan, Sangeeta Shinde," Analysis of Diagrids Using Symmetric and Asymmetric Plan Geometry", International Journal of Recent Advances in Engineering and Technology(IJRAET),Volume -4, Issue-3,2016
- Aman, Manjunath Nalwadgi, Vishal, Gajendra, "Analysis and Design of multistorey building by using STAAD Pro", International Research Journal of Engineering and Technology(IRJET), Volume-3, Issue-03, June2016
- Sabahat J. Ansari, Dr. S.D.Bhole"Comparative Study of Symmetric & Asymmetric L-shaped & T-shaped Multistorey Frame Building Subjected to Gravity & Seismic Loads with Varying Stiffness", IJSTE,Volume-2, Issue-10, April 2016

IS CODES

- IS 875(Part 1) : Dead Load
- IS 875(Part 2) : Live Load
- SP: 34 & IS 13920:1993 (For Reinforcement Ductile Detailing)

SOFTWARE

- SAP 2000
- Auto CAD viz. 2016
- Staad Pro